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**Bonn et al.**

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(54) **PERFUSED CORE DIELECTRICALLY  
LOADED DIPOLE MICROWAVE ANTENNA  
PROBE**

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This patent is subject to a terminal disclaimer.

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(57) **ABSTRACT**

**Related U.S. Application Data**

(63) Continuation of application No. 12/561,096, filed on Sep. 16, 2009, now Pat. No. 8,355,803.

A microwave surgical ablation probe having an arrangement of coolant channels in fluid communication with a cooling chamber disposed within the distal end of the probe is disclosed. A hypotube having one or more longitudinal ribs extending radially inward from an inner surface thereof is coaxially disposed around a coaxial feedline. The longitudinal ribs of the hypotube engage an outer sheath of the feedline to define a fluid inflow channel to deliver coolant to the cooling chamber, and a fluid outflow channel to receive fluid from the cooling chamber. The cooling chamber may be formed from porous ceramic or porous metallic material that provides structural support to the probe while permitting coolant to circulate therethrough. The probe includes dielectric and choke members that are adapted to control the microwave radiation pattern (e.g., ablation shape), and which may provide improved coupling of the probe to tissue.

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USPC ..... **607/156**; 606/33; 606/41

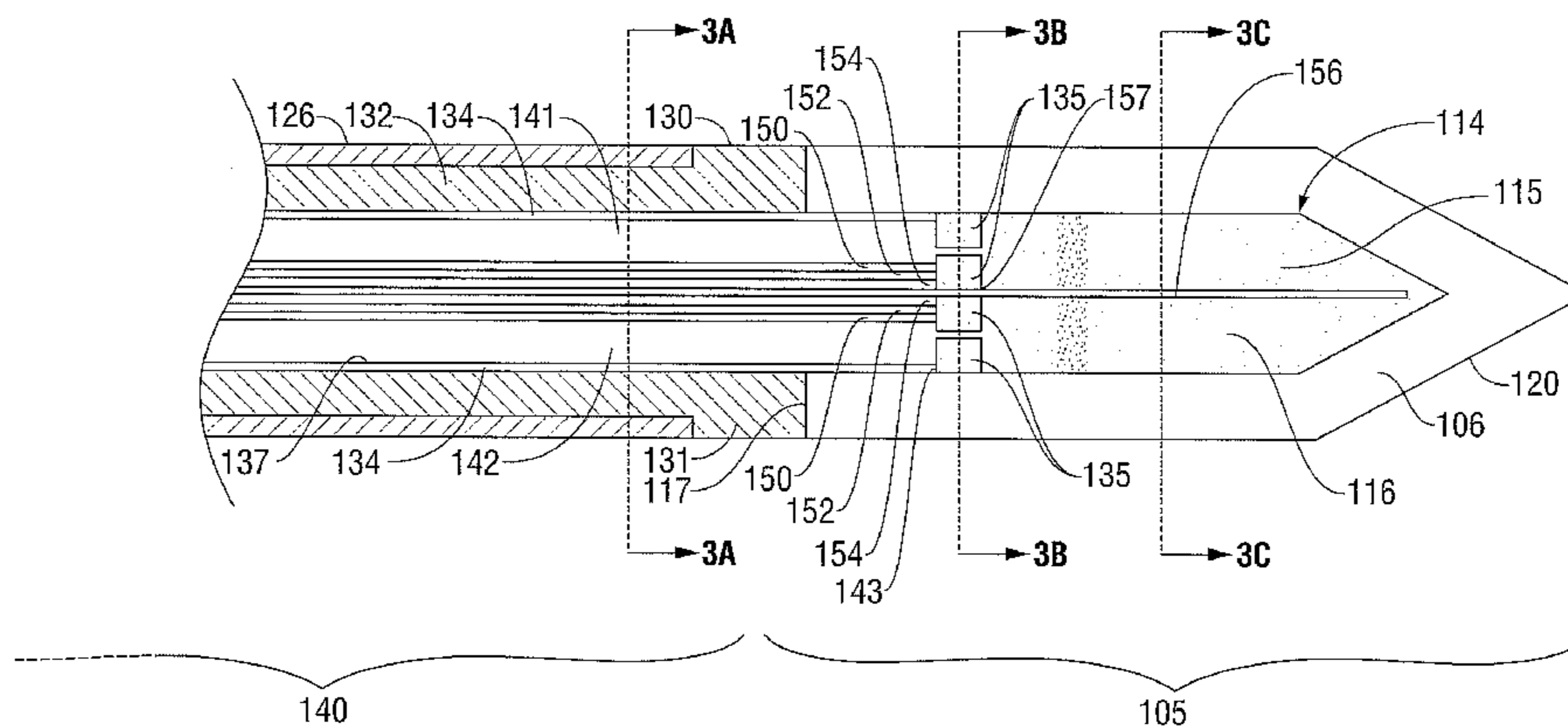
(58) **Field of Classification Search**  
USPC ..... 606/33, 41; 607/156  
See application file for complete search history.

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**20 Claims, 5 Drawing Sheets**



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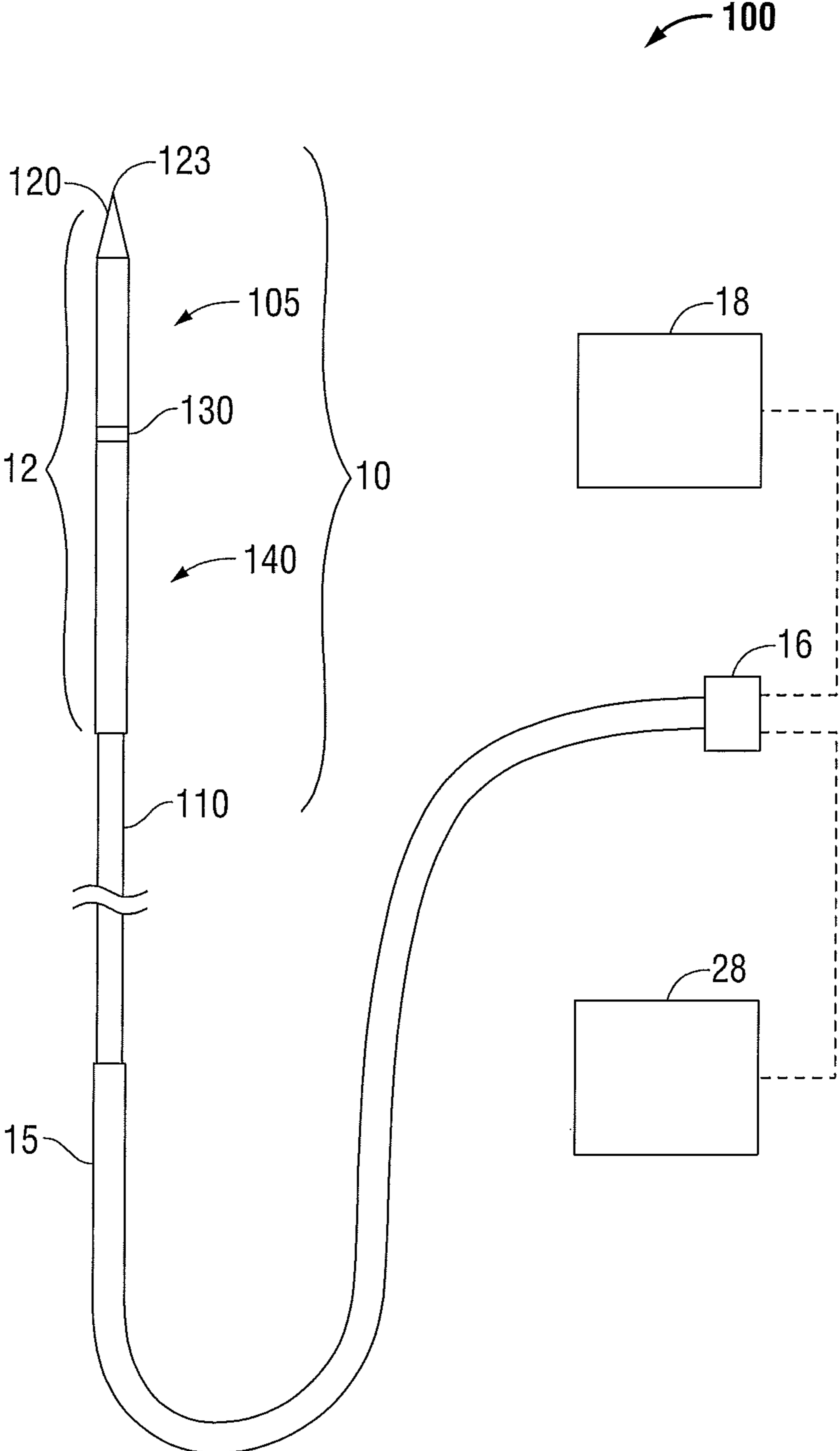


FIG. 1

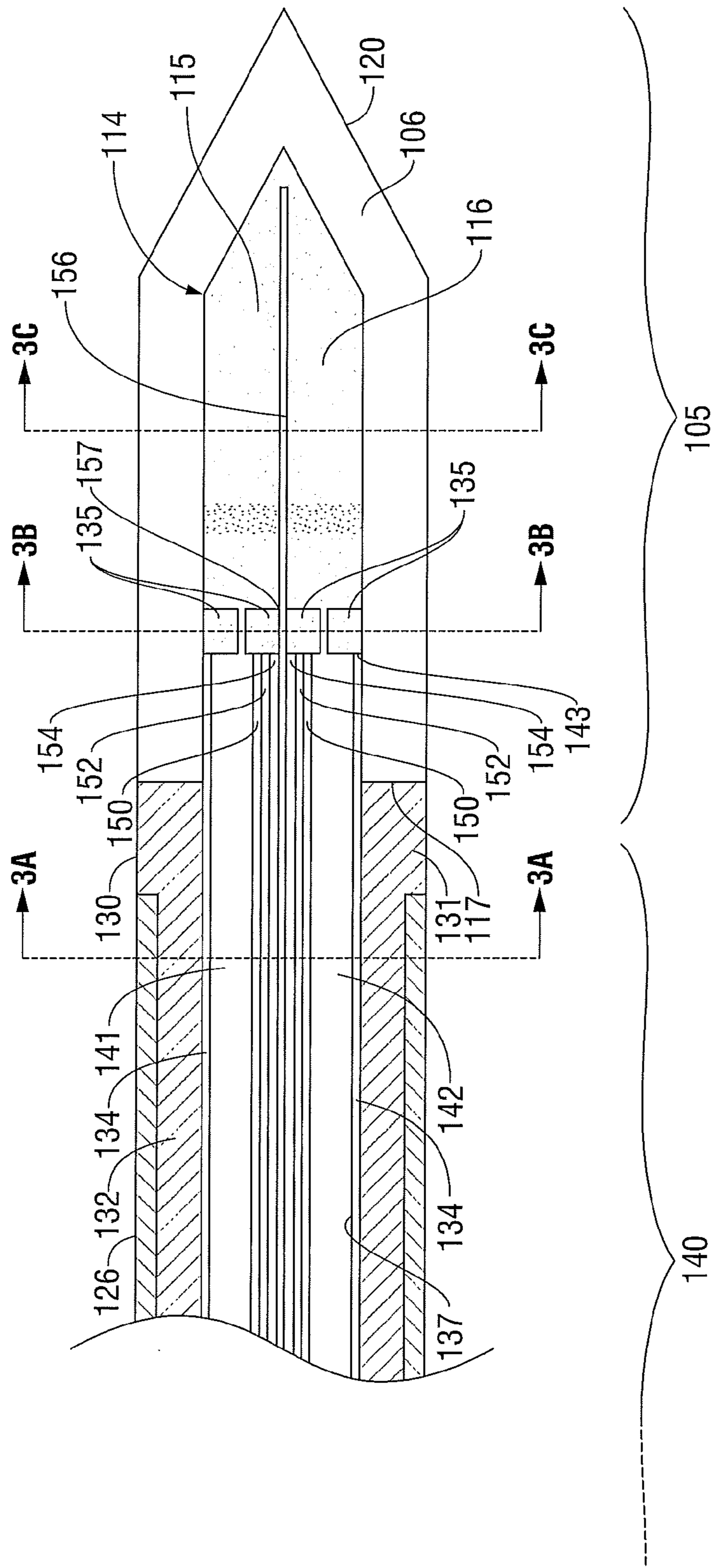


FIG. 2

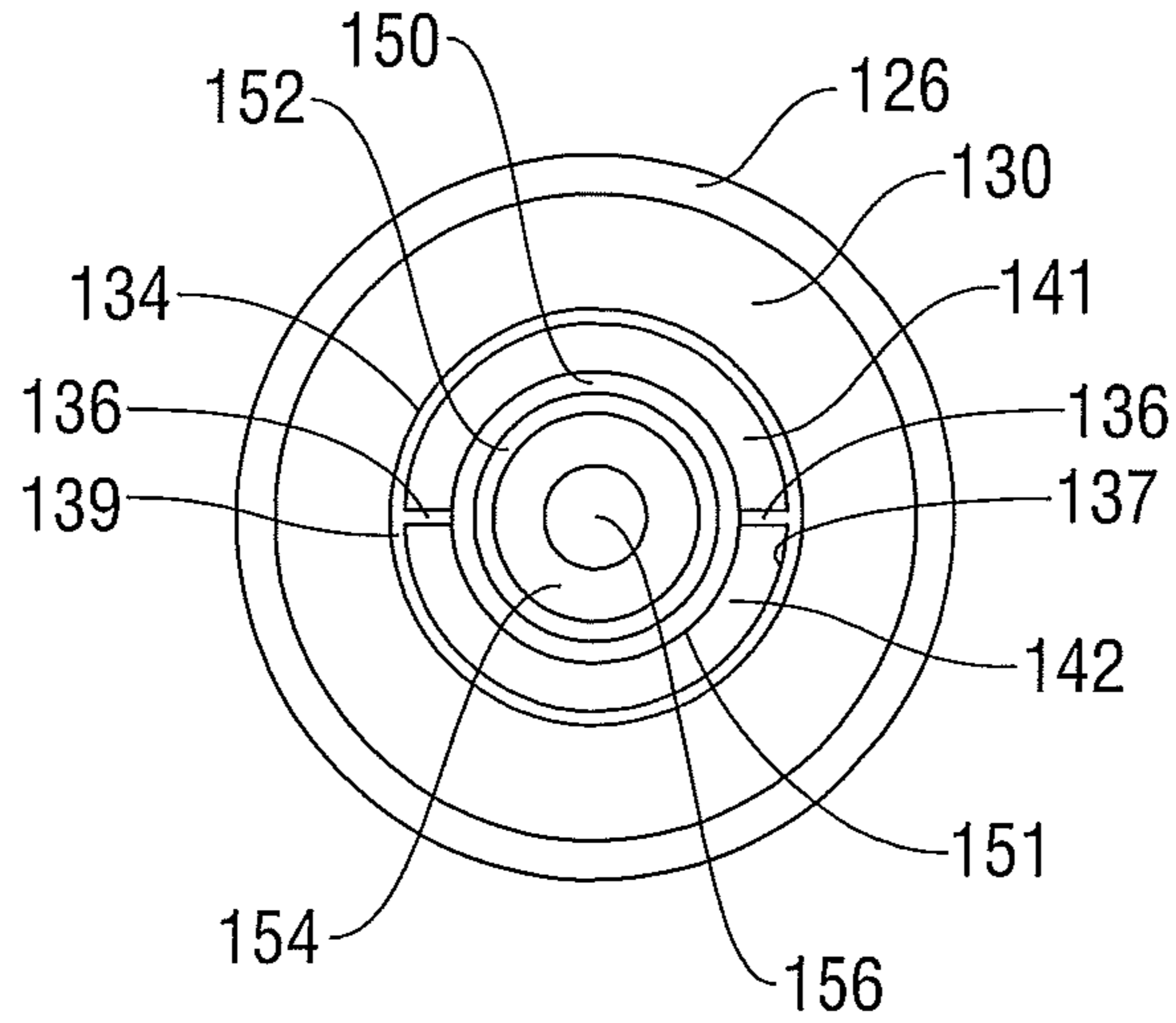


FIG. 3A

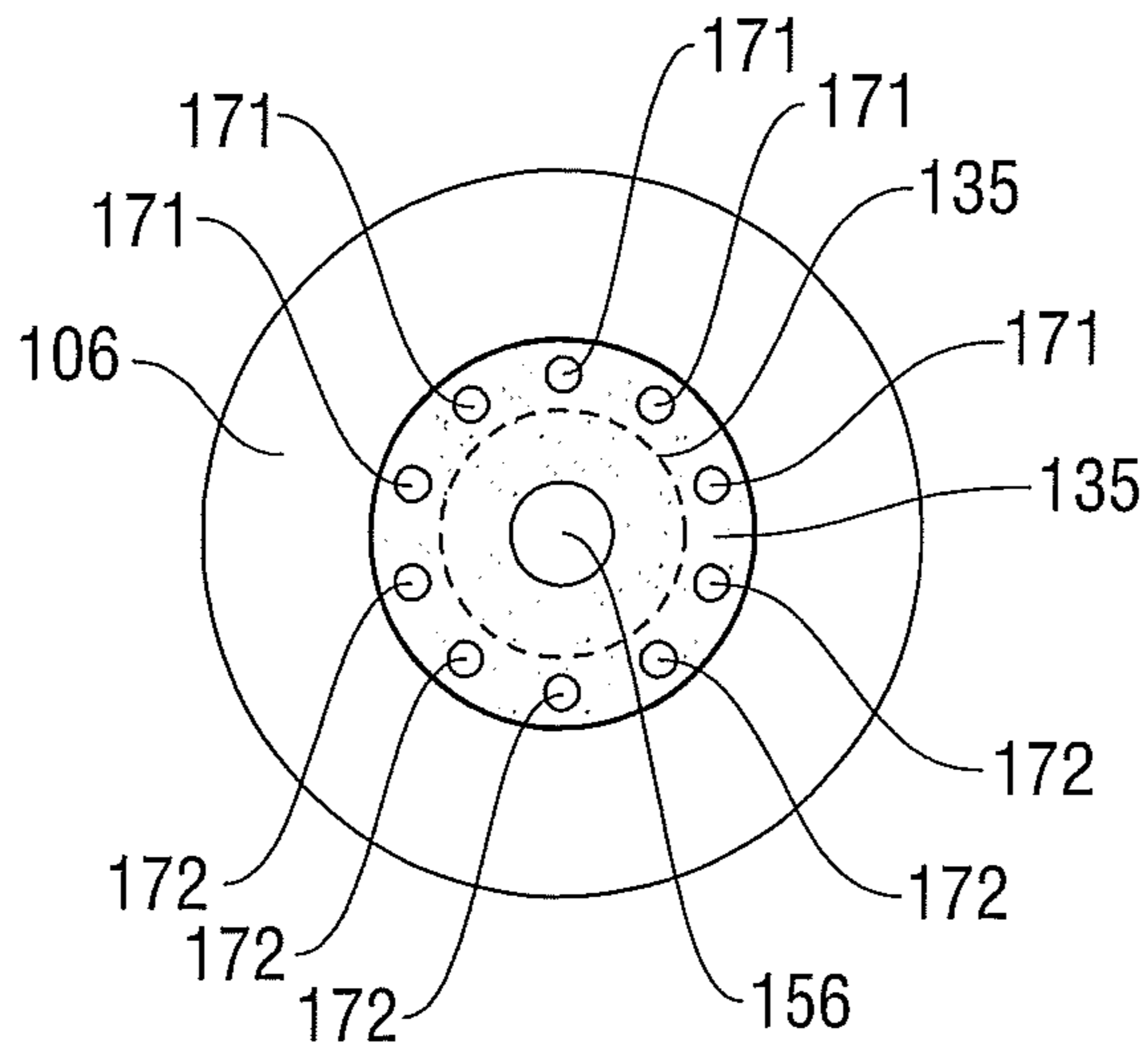


FIG. 3B



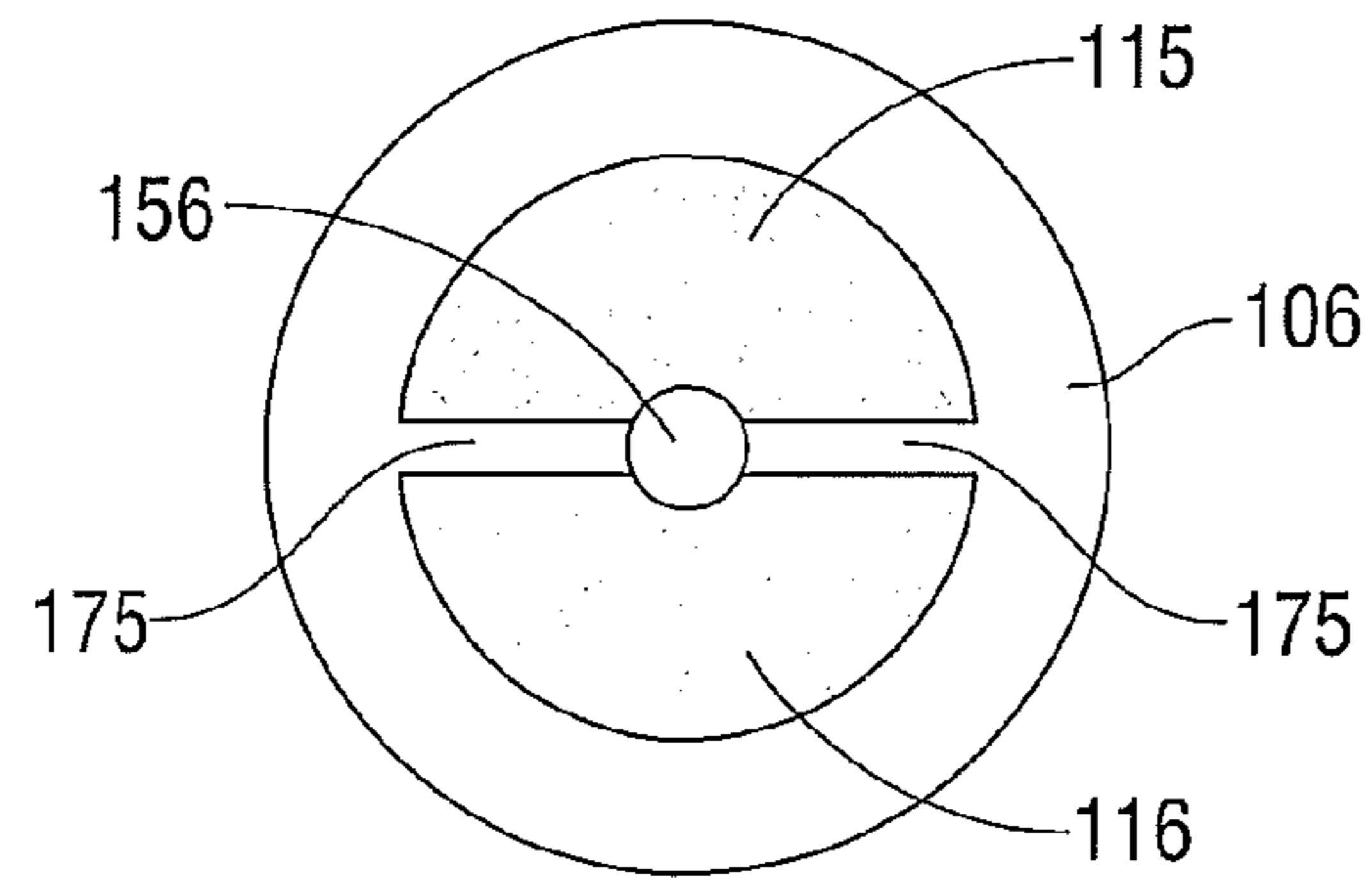


FIG. 3C

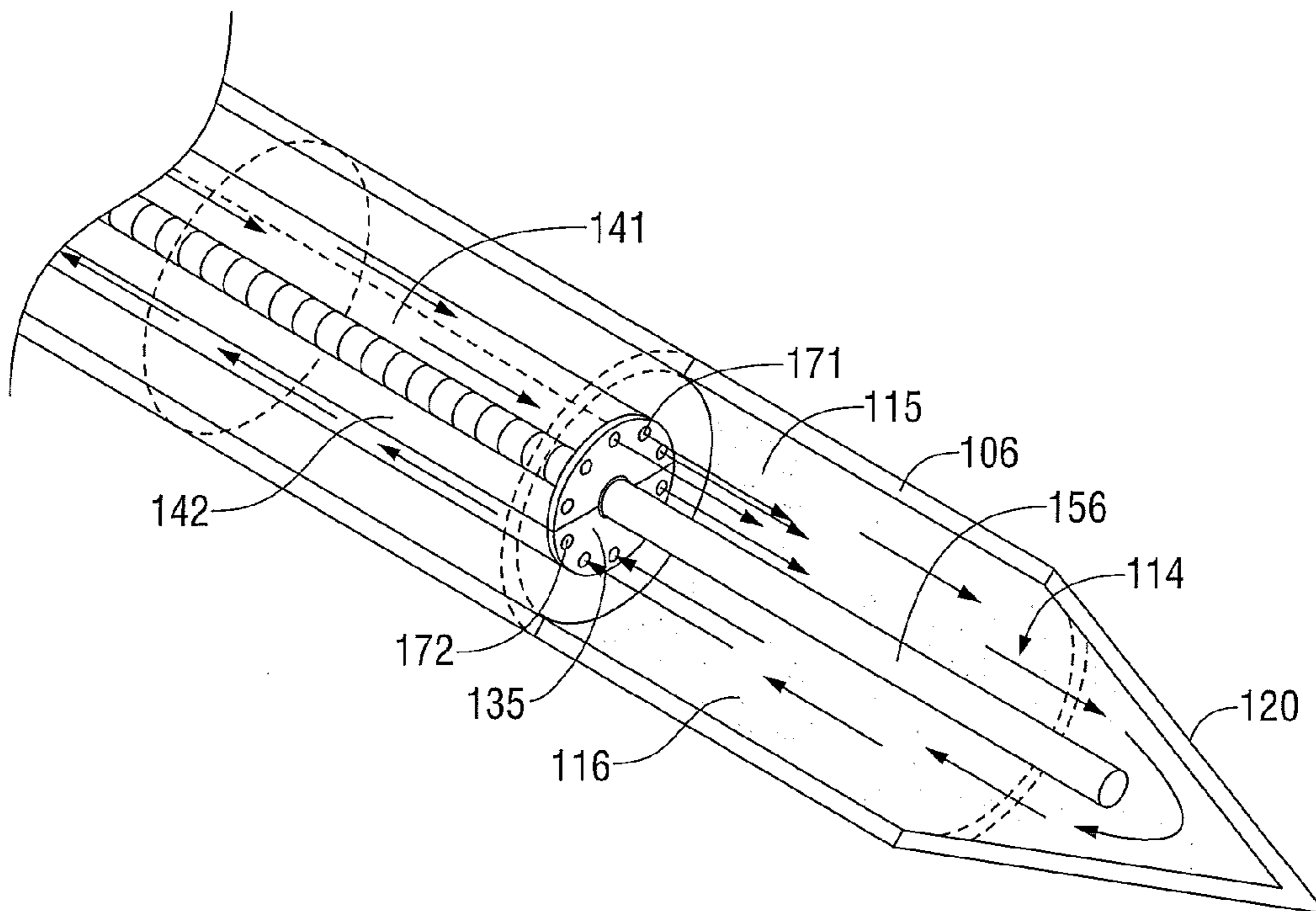


FIG. 4

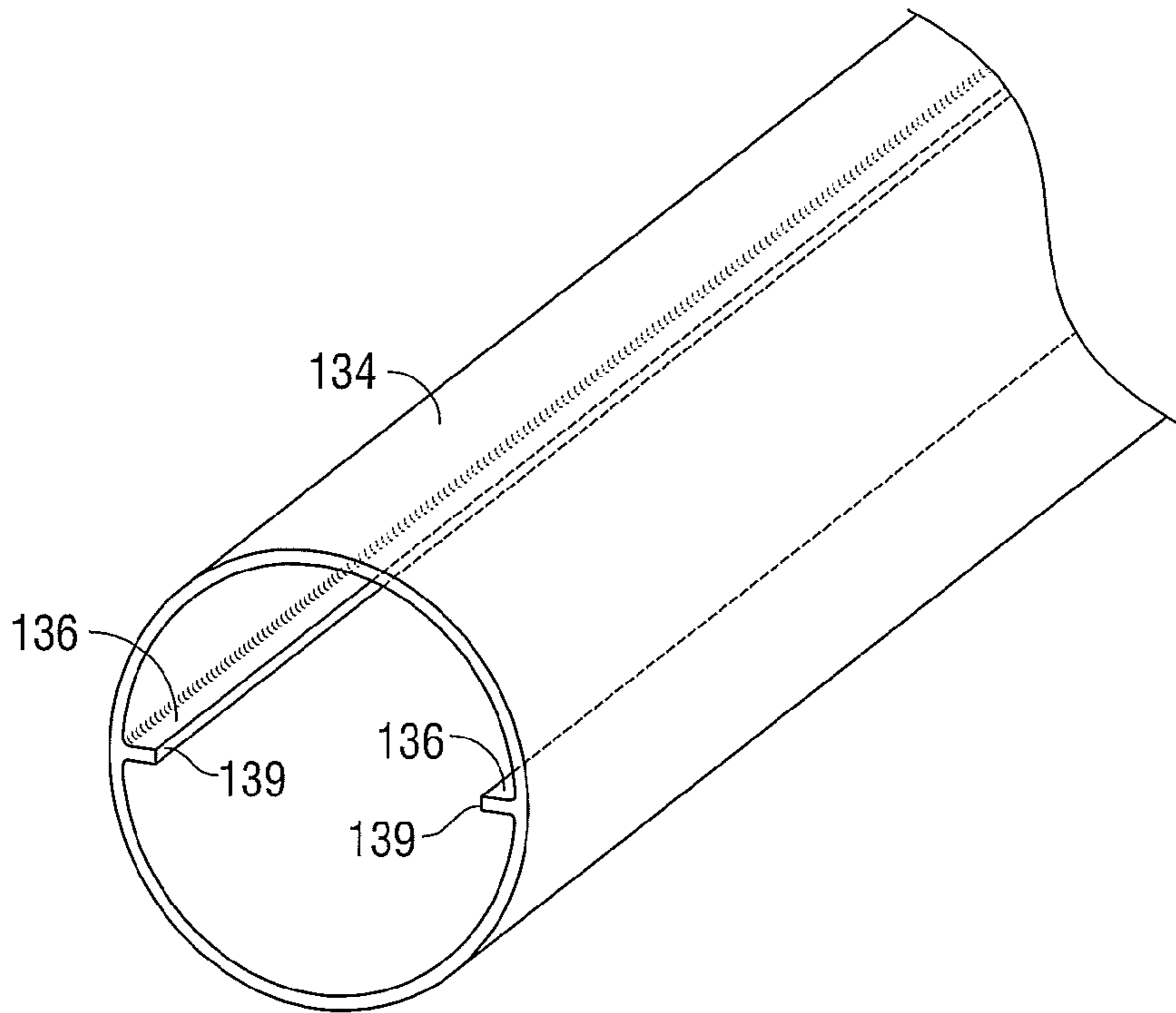


FIG. 5A

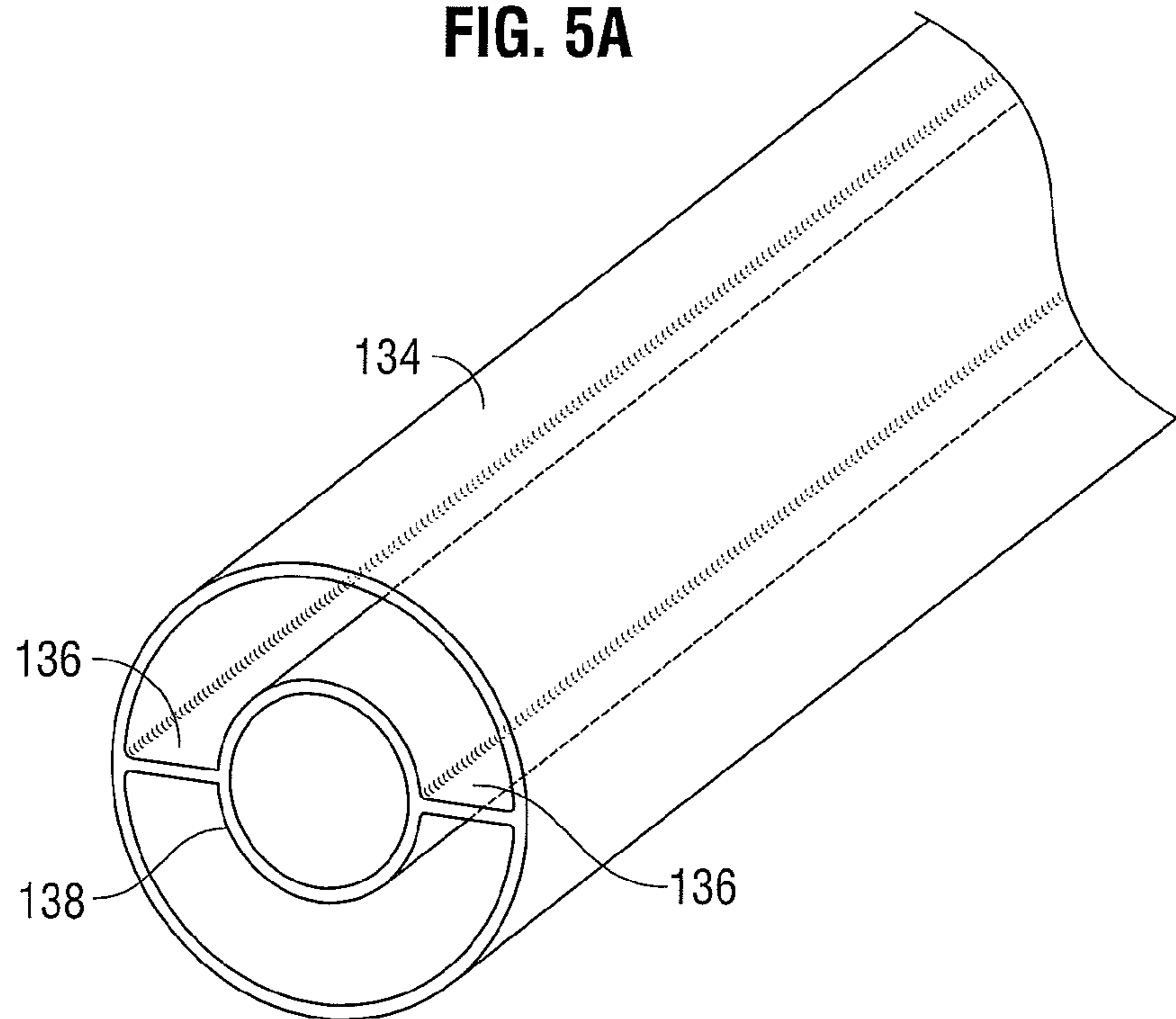


FIG. 5B

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**PERFUSED CORE DIELECTRICALLY  
LOADED DIPOLE MICROWAVE ANTENNA  
PROBE**

CROSS-REFERENCE TO RELATED  
APPLICATION

This application is a Continuation of U.S. patent application Ser. No. 12/561,096, filed Sep. 16, 2009, the entirety of which is hereby incorporated by reference herein for all purposes.

BACKGROUND

1. Technical Field

The present disclosure relates to systems and methods for providing energy to biological tissue and, more particularly, to a microwave ablation surgical probe having a porous core through which coolant is circulated and methods of use and manufacture therefor.

2. Background of Related Art

Energy-based tissue treatment is well known in the art. Various types of energy (e.g., electrical, ultrasonic, microwave, cryogenic, thermal, laser, etc.) are applied to tissue to achieve a desired result. Microwave energy can be delivered to tissue using an antenna probe. Presently, there are several types of microwave probes in use, e.g., monopole, dipole, and helical. One type is a monopole antenna probe, which consists of a single, elongated microwave conductor exposed at the end of the probe. The probe is typically surrounded by a dielectric sleeve. The second type of microwave probe commonly used is a dipole antenna, which consists of a coaxial construction having an inner conductor and an outer conductor with a dielectric junction separating a portion of the inner conductor. The inner conductor may be coupled to a portion corresponding to a first dipole radiating portion, and a portion of the outer conductor may be coupled to a second dipole radiating portion. The dipole radiating portions may be configured such that one radiating portion is positioned proximally of the dielectric junction, and the other portion is positioned distally of the dielectric junction. In monopole and dipole antenna probes, microwave energy generally radiates perpendicularly from the axis of the conductor.

A typical microwave antenna has a long, thin inner conductor that extends along the axis of the probe and is surrounded by a dielectric material and is further surrounded by an outer conductor around the dielectric material such that the outer conductor also extends along the axis of the probe. In another variation of the probe that provides for effective outward radiation of energy or heating, a portion or portions of the outer conductor can be selectively removed. This type of construction is typically referred to as a "leaky waveguide" or "leaky coaxial" antenna. Another variation on the microwave probe involves having the tip formed in a uniform spiral pattern, such as a helix, to provide the necessary configuration for effective radiation. This variation can be used to direct energy in a particular direction, e.g., perpendicular to the axis, in a forward direction (i.e., towards the distal end of the antenna), or combinations thereof.

Invasive procedures and devices have been developed in which a microwave antenna probe may be either inserted directly into a point of treatment via a normal body orifice or inserted percutaneously. Because of the small difference between the temperature required for denaturing malignant cells and the temperature injurious to healthy cells, a known heating pattern and predictable temperature control is important so that heating is confined to the tissue to be treated. For

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instance, hyperthermia treatment at the threshold temperature of about 41.5° C. generally has little effect on most malignant growth of cells. However, at slightly elevated temperatures above the approximate range of 43° C. to 45° C., thermal damage to most types of normal cells is routinely observed.

One approach to controlling probe and/or tissue temperature is to circulate coolant within the probe to extract excess heat from the probe. However, providing coolant passages within a probe may reduce probe strength, because such passages necessitate the introduction of voids into the probe structure.

In some surgical procedures, a microwave antenna probe may be inserted percutaneously into, for example, a chest wall of a patient. During such a procedure, negotiating the probe through, for example, fibrous thoracic tissue and ribs may place undue stresses on the probe. Additionally, a cooled probe may lack sufficient strength to withstand the stresses imposed by such percutaneous insertions, which may result in probe failure.

SUMMARY

The present disclosure provides a high-strength electromagnetic surgical ablation probe that includes a cooled and dielectrically buffered antenna assembly. A cable provides electromagnetic energy to the probe via a coaxial conductor and/or provides coolant via a fluid conduit to improve power delivery performance and power handling, and to reduce component temperatures. Suitable coolants include deionized water, sterile water, or saline.

The disclosed ablation probe includes a coaxial feedline having in coaxial arrangement an outer sheath, an outer conductor, an inner conductor, and a dielectric disposed between the outer conductor and the inner conductor. The inner conductor extends distally beyond the outer sheath, the outer conductor, and the dielectric, e.g., the outer layers of the feedline may be stripped leaving the inner conductor extending distally. A hypotube is coaxially disposed around the feedline. The hypotube includes one or more longitudinal ribs extending radially inward from an inner surface of the hypotube. The ribs extend from the inner surface of the hypotube to an outer surface of the feedline to define one or more fluid channels between the feedline and the hypotube. During manufacture, the ribs may be formed in the hypotube by being drawn into the tubing, extrusion, and/or formed by welding two or more semicircular "clamshell" halves of the hypotube together.

A feed point seal joins a distal end of the hypotube to a porous core enclosed within the probe distal radiating section. The feed point seal includes one or more openings defined therethrough to provide a fluid path between the fluid channels and the porous core. The feed point seal includes an opening, which may be axially positioned, to enable the inner conductor to pass therethrough, e.g., to extend distally into the porous core. The feed point seal additionally or alternatively seals one or more conductors of the feedline, which may help prevent coaxial feedline short circuiting (e.g., shorts between conductors and/or other elements of the probe).

A microwave ablation antenna in accordance with the present disclosure may be configured to operate in a range of about 915 MHz to about 2.45 GHz, or within any other suitable frequency range. In one embodiment, the hypotube ribs press into the coaxial cable thereby forming a separate fluid inflow channel and fluid outflow channel. A coolant, such as saline or dionized water, is introduced into a proximal end of the inflow channel, from where it flows distally, through openings in the feed point seal into a radiating section

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that includes a radiating section having a porous core. The porous core is perfused with coolant, which may help to reduce probe temperatures, and may provide improved dielectric coupling between the probe and tissue. The dual-chamber design of the disclosed probe may provide better coolant dispersion within the probe, thereby providing increased coolant efficiency, and allowing the size of the probe to be greatly reduced.

The porous perfused core may include a separator to define a two chamber perfusion arrangement wherein coolant would first travel distally past the distal radiating section through an inflow chamber region, then return proximally through an outflow chamber region. The porous core may be formed from porous ceramic, porous metal, or any suitable material that permits coolant fluid to circulate. Additionally, the porous core may add strength to the dielectric surface of the probe.

A dielectric coating may enclose the entire probe and act as the dielectric match between the probe and tissue. The coating may act as a sealing layer for the entire probe, and may be formed from lubricious material to facilitate the insertion of the probe percutaneously into tissue.

Also disclosed is a microwave ablation system that includes a source of ablation energy, e.g., a microwave generator, that is operably coupled to a perfused core dielectrically loaded dipole microwave antenna probe as described herein. The disclosed system may include a source of coolant operably coupled to the probe, e.g., to the hypotube.

Also disclosed is a method of manufacturing a perfused core dielectrically loaded dipole microwave antenna probe that includes the steps of providing a hypotube having one or more longitudinal ribs extending radially inward from an inner surface thereof. A coaxial feedline is provided. The coaxial feedline has, in coaxial arrangement, an outer sheath, an outer conductor, an inner conductor, and a dielectric disposed between the outer conductor and the inner conductor. The inner conductor extends distally beyond the outer sheath, the outer conductor, and the dielectric. The inner conductor may be extended by, for example and without limitation, stripping the outer layers of the coaxial feedline to expose the inner conductor. The hypotube is mounted over the feedline to form a fluid channel between the inner surface of the hypotube, the one or more ribs, and an outer surface of the feedline. A feed point seal is overmolded at a distal end of at least one of the hypotube, the sheath, the outer conductor, or the dielectric, and the porous core is mounted to a distal end of the feed point seal.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features, and advantages of the present disclosure will become more apparent in light of the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 shows a diagram of a microwave ablation system having a cooled electromagnetic surgical ablation probe in accordance with an embodiment of the present disclosure;

FIG. 2 shows a cross sectional view of an embodiment of a cooled surgical ablation probe in accordance with the present disclosure;

FIG. 3A shows a section view of the cooled surgical ablation probe of FIG. 2;

FIG. 3B shows another section view of the cooled surgical ablation probe of FIG. 2;

FIG. 3C shows yet another section view of the cooled surgical ablation probe of FIG. 2; and

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FIG. 4 shows a perspective view depicting coolant flow of an embodiment of cooled surgical ablation probe in accordance with the present disclosure;

FIG. 5A shows a detail, perspective view of a hypotube in accordance with the present disclosure; and

FIG. 5B shows a detail, perspective view of another hypotube in accordance with the present disclosure.

#### DETAILED DESCRIPTION

Particular embodiments of the present disclosure will be described hereinbelow with reference to the accompanying drawings; however, it is to be understood that the disclosed embodiments are merely exemplary of the disclosure, which may be embodied in various forms. Well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present disclosure in virtually any appropriately detailed structure.

In the drawings and in the descriptions that follow, the term “proximal,” as is traditional, shall refer to the end of the instrument that is closer to the user, while the term “distal” shall refer to the end that is farther from the user.

FIG. 1 shows an embodiment of a microwave ablation system 100 in accordance with the present disclosure. The microwave ablation system 100 includes an ablation probe 10 connected by a cable 15 to connector 16, which may further operably connect the probe 10 to a generator assembly 28. Probe 10 includes a proximal radiating section 140 and a distal radiating section 105. Distal radiating portion 105 of radiating portion 12 includes a tapered end 120 which terminates at a tip 123 to allow for insertion into tissue with minimal resistance.

Alternatively, tip 123 may be rounded or flat, and may include a forceps or a blade. Generator assembly 28 may be a source of ablation energy, e.g., microwave energy in the range of about 915 MHz to about 2.45 GHz. Cable 15 may additionally or alternatively provide a conduit (not explicitly shown) configured to provide coolant from a coolant source 18 to the ablation probe 10.

With additional reference to FIG. 2, an embodiment of an ablation probe 100 includes a coaxial feedline 110 that extends from a proximal end of the probe 10, which may include a handle (not explicitly shown), wherein the coaxial feedline 110 is adapted to provide radiofrequency and/or microwave ablation energy to the probe 10 generally, and more specifically, to proximal radiating portion 140 and distal radiating portion 105. Coaxial feedline 110 may exhibit an impedance of 50Ω. Coaxial feedline 110 includes, in coaxial arrangement, an outer coaxial conductor 152, a dielectric layer 154 coaxially disposed within outer coaxial conductor 152, and an inner conductor 156 coaxially disposed within dielectric layer 154. Inner conductor 156 of coaxial feedline 110 extends distally through a feed point seal 135 into porous core 114, as will be described further hereinbelow. An insulating outer sheath 150 may be coaxially disposed around outer coaxial conductor 152.

A tubular hypotube 134 is positioned coaxially around feedline 110 to form one or more fluid channels 141, 142. Hypotube 134 extends from a proximal end of the probe 10 to the feed point seal 135. Hypotube 134 includes one or more dividing ribs 136 (FIG. 3A) positioned longitudinally along an inner surface 137 of hypotube 134. Dividing ribs 136 are dimensioned to extend from an inner surface 137 of hypotube

**134** to an outer surface **151** of outer sheath **150** of feedline **110**, as seen in FIGS. **3A** and **5A**. Inner edge **139** of rib **136** is adapted to engage the outer sheath **150** of feedline **110**. In an embodiment, ribs **136** are dimensioned to press into outer sheath **150** to form a fluid-tight seal. Additionally or alternatively, hypotube **134** may have a double-walled construction as best seen in FIG. **5B**, wherein ribs **136** extend inwardly to an inner hypotube tube **138** concentrically positioned therein. Inner hypotube **138** has an inner diameter dimensioned to receive feedline **110**, e.g., the inner diameter of inner hypotube **138** is about equal to the outer diameter of outer sheath **150**.

Hypotube **134** and ribs **136** (as arranged around outer sheath **150** and/or inner hypotube **138**) define a fluid inflow channel **141** and a fluid outflow channel **142**, each having a proximal end and a distal end. A proximal end of fluid inflow channel **141** may be in operable fluid communication with a source of coolant **18**, such as without limitation, saline and/or deionized water. A proximal end of fluid outflow channel **142** may be configured to expel spent coolant. Additionally or alternatively, outflow channel **142** may be configured to direct spent fluid to a reservoir (not explicitly shown), and/or to direct coolant to a circulator for re-use.

Continuing with reference to FIG. **3B**, feed point seal **135** is positioned at a distal end **143** of hypotube **134**. Feed point seal **135** includes one or more inflow holes **171** and/or outflow holes **172** defined therein that are adapted to permit the passage of coolant through feed point seal **135**. Inflow holes **171** are positioned at a distal end of inflow channel **141** and are adapted to direct coolant to flow from inflow channel **141** into an inflow region **115** of porous core **114**. Outflow holes **172** are positioned at a distal end of outflow channel **142** and are adapted to direct coolant flow from an outflow region **116** of porous core **114** to outflow channel **142**.

As shown in FIG. **4**, during use, coolant flows distally through inflow channel **141**, through inflow holes **171**, and into an inflow region **115** of porous core **114**. Coolant flows proximally from an outflow region **116** of porous core **114**, through outflow holes **172**, and continues proximally through outflow channel **142**. Coolant circulating through porous core **114** in the described manner cools distal radiating section **105** and/or tip **120**, and may dielectrically load ablation energy radiating from inner conductor **156** to tissue. Feed point seal **135** includes a center opening **157** defined therein that is configured to accommodate the passage of inner conductor **156** therethrough and to provide a fluid-tight seal to prevent leakage or backflow of coolant into coaxial feedline **110**.

Feed point seal **135** is sealably coupled to hypotube **134** using any suitable manner of fluid sealing. Feed point seal **135** may additionally or alternatively form a fluid-tight seal around inner conductor **156**. Feed point seal **135** may additionally or alternatively encapsulate a distal end of one or more of outer sheath **150**, outer conductor **152**, and/or dielectric layer **154**, which may prevent electrical short circuiting therebetween. Feed point seal **135** may be formed by overmolding over a distal end **143** of hypotube **134**, e.g., formed by molding feed point seal **135** in place thereby forming a fluid-tight seal between a distal end **143** of hypotube **134** and feed point seal **135**. Feed point seal **135** may be formed from any suitable material that can withstand probe operating temperatures and that is electrically non-conductive, for example without limitation, polyether block amide, such as Pebax®, manufactured by The Arkema Group of Colombes, France; polyetherimide (PEI), such as Ultem® and/or Extem®, manufactured by SABIC Innovative Plastics of Saudi Arabia;

and/or polyimide-based polymer, such as Vespel®, manufactured by E.I. du Pont de Nemours and Company of Wilmington, Del., United States.

Distal radiating section **105** includes an outer dielectric surface **106** and a porous core **114** therein. Porous core **114** may include an inflow region **115** and an outflow region **116** having a separator **175** disposed therebetween. One or more openings (not explicitly shown) may be defined within separator **175** to enable coolant to flow from inflow region **115** to outflow region **116**. Porous core **114** may be formed from any suitable material that provides radial support to outer dielectric surface **106** and that enables coolant perfusion within porous core **114**. For example, and without limitation, porous core **114** may be formed from a porous ceramic material having an open cell, closed cell, tangle fiber network, and/or membrane structure. In an embodiment, porous core **114** may be formed from a metallic material, such as without limitation, stainless steel, titanium, nickel, nickel alloys, and bronze formed by any suitable manner of manufacture, e.g., powder compaction sintering, gravity sintering, powder rolling and sintering, isostatic compaction and sintering, metal spraying, metal coating and sintering, metal injection molding and sintering, and/or any other suitable manner of porous metal forming.

As best illustrated in FIG. **2**, probe **10** includes a substantially cylindrical dielectric choke **130** concentrically disposed about a proximal portion of hypotube **134** wherein an inner diameter of dielectric choke **130** is about equal to an outer diameter of hypotube **134**. Dielectric choke includes a distal portion **131** that has an outer diameter about equal to the outer diameter of distal radiating section **105**, and includes a proximal portion **132** that has an outer diameter about equal to an inner diameter of a tubular choke outer jacket **126**. Choke outer jacket **126** may be formed from any suitable heat-resistant metallic material, e.g., stainless steel. Dielectric choke **130** may be formed from material having low electrical conductivity at probe operating frequencies, e.g., elastomeric polymers, epoxy-fiber composites, and the like. A distal end **131** of dielectric choke **130** is joined to a proximal end **117** of outer dielectric surface **106**. Hypotube **134** extends distally beyond a distal end **131** of dielectric choke **130** and/or extends distally beyond a proximal end **117** of outer dielectric surface **106** such that feed point seal **135** is positioned within outer dielectric surface **106** at a point distally of proximal end **117** of outer dielectric surface **106**.

An outer surface of the probe **10**, e.g., an outer surface of choke outer jacket **126**, dielectric choke **130**, dielectric surface **106**, and/or tip **120**, may include a dielectric coating (not explicitly shown). The dielectric coating may be formed from any suitable material having the ability to withstand the operating temperature of the probe and having a low electrical conductivity at probe operating frequencies, such as without limitation, polytetrafluoroethylene (a.k.a. PTFE or Teflon®, manufactured by the E.I. du Pont de Nemours and Co. of Wilmington, Del., USA), polyethylene tephthalate (PET), or the like. Additionally or alternatively, an outer surface of the probe **10** as previously described may include a heat shrink covering, such as polyolefin tubing, or any suitable heat-shrink material. The dielectric coating and/or heat shrink covering may provide a lubricious interface between the probe **10** and tissue to reduce or prevent undesirable adhesion of tissue to the probe **10**, and to aid insertion of the probe **10** into tissue.

A method of manufacturing an ablation probe **10** in accordance with the present disclosure includes the steps of providing a hypotube **134** having one or more longitudinal ribs **136** extending radially inward from an inner surface **137**

thereof. Hypotube **134** and/or ribs **136** may be formed by any suitable manner of manufacture, including without limitation by extrusion and/or welding. Hypotube **134** may be constructed by joining two or more semicircular sections (not explicitly shown) along a common longitudinal edge thereof to form the generally tubular shape of hypotube **134**. A coaxial feedline **110** may be provided, wherein the feedline includes (in coaxial arrangement) an outer sheath **150**, an outer conductor **152**, an inner conductor **156**, and a dielectric **154** disposed between the outer conductor **152** and the inner conductor **156**, wherein the inner conductor **156** extends distally beyond the outer sheath **150**, the outer conductor **152**, and the dielectric **154**. The inner conductor **156** may be extended by stripping outer sheath **150**, outer conductor **152**, and dielectric **154** as will be familiar to the skilled artisan.

Hypotube **134** is mounted over the feedline **110** to form one or more fluid channels defined between an inner surface **137** of hypotube **134**, the one or more ribs **136**, and an outer surface of the sheath (not explicitly shown). A distal end **143** of hypotube **134** is substantially aligned with a distal end of outer sheath **150**, outer conductor **152**, and/or dielectric **154**. A feed point seal **135** may be mounted at a distal end of at least one of the sheath **150**, the outer conductor **152**, or the dielectric **154**. The feed point seal **135** may be formed in place by overmolding whereby the sheath **150**, the outer conductor **152**, and/or the dielectric **154** are encapsulated within the feed point seal **135**. During the overmolding step, the inner conductor **156** extends distally through the feed point seal **135**. In this manner, a fluid-tight seal may be formed between inner conductor **156** and feed point seal **135**.

A proximal end of porous core **114** is mounted to a distal end of the feed point seal **135**. Porous core **114** may be mounted within distal radiating section **105** and/or tip **120**. Porous core **114** may additionally or alternatively be formed within distal radiating section **105** and/or tip **120**, and mounted to a distal end of the feed point seal. Feed point seal **135** may additionally or alternatively be overmolded over the combination of feedline **110** (including without limitation sheath **150**, outer conductor **152**, dielectric **154**, and/or inner conductor **156**) and porous core **114**.

The described embodiments of the present disclosure are intended to be illustrative rather than restrictive, and are not intended to represent every embodiment of the present disclosure. Further variations of the above-disclosed embodiments and other features and functions, or alternatives thereof, may be made or desirably combined into many other different systems or applications without departing from the spirit or scope of the disclosure as set forth in the following claims both literally and in equivalents recognized in law.

What is claimed is:

**1.** An ablation probe, comprising:

a feedline having an outer sheath, an inner conductor, and an insulator coaxially disposed around the inner conductor, wherein the inner conductor extends distally beyond the outer sheath and the insulator;

a hypotube coaxially disposed around the feedline having two longitudinal ribs that extend radially inward from an inner surface of the hypotube to an outer surface of the feedline to define an inflow fluid channel and an outflow fluid channel;

a feed point seal operably coupled to a distal end of the hypotube and including a first opening and a second opening defined therethrough, each having a proximal end and a distal end, wherein the proximal end of the first opening is disposed in fluid communication with the

inflow fluid channel and the proximal end of the second opening is disposed in fluid communication with the outflow fluid channel;

a distal radiating section having a cylindrical outer dielectric surface, and a generally conical tip disposed at a distal end of the distal radiating section, the cylindrical outer dielectric surface and conical tip defining a cooling region therein; and

a porous core closed within the cooling region and in fluid communication with the distal end of the first opening of the feed point seal and the distal end of the second opening of the feed point seal.

**2.** The ablation probe in accordance with claim **1**, wherein the inner conductor extends distally through a third opening defined in the feed point seal.

**3.** The ablation probe in accordance with claim **1**, wherein the inner conductor extends distally into the porous core.

**4.** The ablation probe in accordance with claim **1**, wherein the feed point seal is formed from material selected from the group consisting of polyether block amide, polyetherimide, and polyimide-based polymer.

**5.** The ablation probe in accordance with claim **1**, wherein the feed point seal encapsulates a distal end of at least one of the outer sheath and the insulator.

**6.** The ablation probe in accordance with claim **1**, wherein the porous core includes a separator adapted to define an inflow region of the porous core and an outflow region of the porous core.

**7.** The ablation probe in accordance with claim **6**, wherein the inflow region and the outflow region are disposed in fluid communication through a separator opening defined in the separator.

**8.** The ablation probe in accordance with claim **1**, wherein the porous core is formed from material selected from the group consisting of porous metal and porous ceramic.

**9.** The ablation probe in accordance with claim **1**, further comprising a dielectric choke concentrically disposed around at least a portion of the hypotube.

**10.** The ablation probe in accordance with claim **9**, where the dielectric choke includes an outer jacket concentrically disposed around at least a portion thereof.

**11.** An ablation system, comprising:

a source of microwave ablation energy;

a source of coolant;

a feedline operatively coupled to the source of microwave ablation energy, wherein the feedline includes an outer sheath, an inner conductor, and an insulator coaxially disposed around the inner conductor, wherein the inner conductor extends distally beyond the outer sheath and the insulator;

a hypotube operatively coupled to the source of coolant wherein the hypotube is coaxially disposed around the feedline and includes at least two longitudinal ribs that extend radially inward from an inner surface of the hypotube to an outer surface of the feedline to define an inflow fluid channel and an outflow fluid channel;

a feed point seal operably coupled to a distal end of the hypotube and including a first opening and a second opening defined therethrough, each having a proximal end and a distal end, wherein the proximal end of the first opening is disposed in fluid communication with the inflow fluid channel and the proximal end of the second opening is disposed in fluid communication with the outflow fluid channel;

a distal radiating section having a cylindrical outer dielectric surface, and a generally conical tip disposed at a

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distal end of the distal radiating section, the cylindrical outer dielectric surface and the conical tip defining a cooling region therein; and

a porous core closed within the cooling region and in fluid communication with the distal end of the first opening of the feed point seal and the distal end of the second opening of the feed point seal.

**12.** The ablation system in accordance with claim **11**, wherein the inner conductor extends distally through a third opening defined in the feed point seal.

**13.** The ablation system in accordance with claim **11**, wherein the inner conductor extends distally into the porous core.

**14.** The ablation system in accordance with claim **11**, wherein the feed point seal is formed from material selected from the group consisting of polyether block amide, polyetherimide, and polyimide-based polymer.

**15.** The ablation system in accordance with claim **11**, wherein the feed point seal encapsulates a distal end of at least one of the outer sheath and the insulator.

**16.** The ablation system in accordance with claim **11**, wherein the porous core includes a separator adapted to define an inflow region of the porous core and an outflow region of the porous core.

**17.** The ablation system in accordance with claim **16**, wherein the inflow region and the outflow region are disposed in fluid communication through a separator opening defined in the separator.

**18.** A method of manufacturing an ablation probe, comprising the steps of:

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forming a hypotube having at least two longitudinal ribs that extend radially inward from an inner surface thereof;

providing a coaxial feedline having in coaxial arrangement an outer sheath, an inner conductor, and an insulator coaxially disposed around the inner conductor, wherein the inner conductor extends distally beyond the outer sheath and the insulator;

mounting the hypotube over the feedline to form an inflow fluid channel and an outflow fluid channel between an inner surface of the hypotube, the at least two ribs, and an outer surface of the sheath;

forming a feed point seal at a distal end of at least one of the sheath or the insulator;

forming a distal radiating section having a cylindrical outer dielectric surface, and a generally conical tip disposed at a distal end of the distal radiating section, the cylindrical outer dielectric surface and conical tip defining a cooling region therein; and

closing a porous core within the cooling region.

**19.** The method of manufacturing an ablation probe in accordance with claim **18**, wherein forming a hypotube includes joining two or more semicircular sections.

**20.** The method of manufacturing an ablation probe in accordance with claim **18**, wherein forming a hypotube includes longitudinal ribs being formed in the hypotube by being drawn into the tubing, formed by extrusion, and/or formed by joining two or more semicircular clamshell halves of the hypotube.

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